COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT

MITCHELL W. TINDER
COMMISSIONER OF HIGHWAYS

ADDRESS REPLY TO
DEPARTMENT OF HIGHWAYS
DIVISION OF RESEARCH
132 GRAHAM AVENUE
LEXINGTON, KENTUCKY 40506

January 31, 1967

H.2.14

MEMORANDUM

TO: W. B. Drake, Assistant Projects Management Engineer; Chairman, Kentucky Highway Research Committee

SUBJECT: "Investigation of Design, Construction, and Erosion Control Methods for Use in Wind-blown Silts;" KYHPR-64-14, HPR-1(1), Part II.

As you know, the construction of the Henderson By-Pass, U 526 (23), in 1962, was frought with various aberrant problems arising from massive deposits of wind-blown silts prevailing in the area. Previous thereto, problems had arisen in connection with the dam in Audubon Park nearby and in the design and construction of the Mayfield Airport--both involving silts. Street construction in Owensboro has been similarily afflicted. Present U. S. 60 between Henderson and Owensboro traverses silt deposits, but we do not know if any problems were experienced in the original construction (early 1930's); however, the pavements have performed well, and the near-vertical cut slopes persist today. Of course, the Henderson By-Pass, and especially the U. S. 60 interchange involved vastly more extensive earthwork--in material inherently sensitive to disturbance.

The Green River valley and the Pond Creek area to the northeast of Madisonville consists of vast bottoms of silty soils--apparently water-deposited but evidently more prominently associated with wind-blown material toward the Ohio River. Severe settlements and fracturing of highway fills crossing these bottoms are evident on Ky 70 and 81.

As a consequence of the Henderson By-Pass episode, the Division of Research planned to make an intensive case study there and to resolve guidelines for any future construction there and in similarily suspect areas. The study was begun, but unfortunately, was not consummated at that time--but was programmed under Part II of HPS-HPR-1(25), the Department's planning and research activities conducted cooperatively with the Bureau of Public Roads (fiscal year '63-'64). It was re-programmed each year until '66-'67 but no further progress was made; it was deleted from the '66-'67 program, HPR-1(2),--thinking that we should not further compound our delinquency into record. This was previous to the inception or reality of the Pennyrile Parkway and was subsequently regretted. Nevertheless, I, thereafter, related our interest and aspirations in these matters to Mr. Gaither, Director of Design, who responded with a memorandum request, September 15, 1966, for any information and recommendations which we might furnish pertaining to the Parkway. We have overrun our schedule again; and our report, submitted herewith, is even now an expedient one. It illustrates, at least, the ideas and criteria we had in mind. Some important points in Dr. Deen's report are summarized below:

1. Silts frequently become "quick" when disturbed, are difficult to drain and dewater, and frequently have to be excavated with a dragline and air-dried to "optimum" when placed in fills and compacted.

2. They exhibit high strengths when properly compacted and are suitable for most uses when handled properly.

3. Silts disturbed and recompacted should be protected from rain and infiltration --otherwise densities may be lost. Finished embankments and subgrades might be primed and water-proofed immediately in order to avoid having to rework areas repetitively.

4. Erosion of all slopes and drainage ways may incur enormous losses of material from the construction site, cause filling of streams, and damage adjacent properties unless mulching and seeding follow immediately behind the earthwork. Final dressing of slopes and slope protection should follow immediately behind an orderly progression of rough grading.

Perhaps this report and the experiences gained from the Pennyrile Parkway will serve as a basis for the further development of a master criterion.

Respectfully submitted,

Jas. H. Havens

Jas. H. Havens
Director of Research
Secretary, Research Committee

JHH:mm
Attachment
cc: Research Committee
A. O. Neiser
R. A. Johnson
T. J. Hopgood
R. O. Beauchamp
J. T. Anderson
O. W. Edwards
G. F. Kemper
H. G. Mays
Charles Henry

Research Report

HIGHWAY CONSTRUCTION IN WINDBLOWN SILTS OF WESTERN KENTUCKY

BY

Robert C. Deen
Assistant Director

Division of Research
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

January, 1967

REGIONAL CONCEPT

It has been shown (1) that engineering experience and performance histories of earthwork structures and foundations in distinctive physiographic regions provide valuable insights applicable to the planning and construction of future projects. Geologic information further categorizes earth materials on the basis of parent material and geologic processes which modify the rock and soil masses. A knowledge of the resulting topographic expression or landforms and reference to geologic and soils information contained in surveys, reports, and maps is particularly useful in the early stages of planning and site selection. When sufficient information is available, regional units may be recognized for the purpose of delineating engineering behavior of the earth materials. Such regional approaches have been demonstrated to be valid for the State of Kentucky in recognizing certain areas which are potentially hazardous with the regard to landslides (2) and engineering performance of soils (3).

SILT-SIZE SOILS
(0.05-0.005 mm Material)

The eolian or wind-deposited silts (loess) are widely distributed and cover extensive areas in central Europe, southern USSR, norther China, Argentina, and the United States. These wind-deposited silts often may be intermixed with soils of other origins but more often than not are noted for their remarkable uniformity within a given deposit. In many areas, the deposits are of such shallow depth that the loessal materials generally have little influence upon the physiography of the area. In other areas, however, the silt may have been deposited to greater depths and present formidable engineering problems.

Extensive areas of loess deposits in the United States are known in 1) the Walla Walla Section of the Columbia Plateau (eastern Washington and north-central Oregon), 2) the High Plains of eastern Colorado and western Nebraska and Kansas, 3) the Snake River Plains of the Columbia River Plateau, 4) the Central Lowlands in eastern Nebraska and Kansas, Idaho, South Dakota, Missouri, Minnesota, Wisconsin, Illinois, and Indiana, and 5) the Mississippi Upland of the Gulf Costal Plain. In the Palouse area of the Walla Walla Section, the windblown silts are relatively deep and are of glacial origin. The loess in this area consists of 70-80 percent silt, 10 percent sand and 20 percent clay. The topography is generally rolling and the area is used extensively for raising wheat crops. Precipitation in the area is 10 to 25 inches per year. In the Snake River Plains of the Columbia

Plateau, the windblown silts are relatively shallow. The loess is of desert origin, derived from the young lava flow and associated with very minor amounts of precipitation in the area. This is probably the sandiest loess in the United States. In the Dissected Loessal and Till Plains of Kansas, Nebraska, and Iowa, the windblown silts are relatively shallow and overlay deep gumbotils. The silt is of glacial and desert origin. The area is poorly drained because of the influence of the underlying gumbotils. The topography is highly dissected and as a result there is a great deal of variation in soil properties and performances as one goes from loess to gumbotil. In the Missouri Valley, the loess consists of approximately 85-90 percent silt and 10 to 15 percent clay and sand. In the upper Mississippi River Valey (the Midwest) the loess layers are relatively thin and of alluvial origin. These deposits predominately contain more clays than most other loess deposits in the United States. The Mississippi Loessal Uplands are of alluvial origin and have a significant problem of perched water tables.

In residual soil areas, the thickness of the silty horizon depends largely upon the parent material, topography, and the length of time of weathering. The silt layer is normally the surface mantle and is generally thin, However, in areas such as the Piedmont region, relatively deep covers of silty, micaceous soils predominant and have been derived from parent bedrock which tends to the development of such soils. Widespread water-deposited silt may be found in North America in the form of lacustrine, marine, and alluvial materials. Significant areas of these silty materials can be found in the alluvium of the major rivers. In Kentucky, the majority of the water-deposited silts are associated with the streams and rivers.

Eolian silts in Kentucky are predominantly associated with the Mississippi Loessal Uplands which extend along the east bank of the flood plains of the Mississippi River from New Orleans to the mouth of the Ohio River. These windblown silts have been deposited by the prevailing westerlies over Coastal Plain materials. The silts may be as thick as 100 feet along the Mississippi River and thin out over a distance of some 40 or 50 miles east of the river. The topography of the loess in the Mississippi River Valley is distinctly hilly along the western edge where it is the deepest. Where the material becomes much thinner to the east, the surface topography assumes the character of the underlying Coastal Plain materials, which are undulating to flat. Limited areas of exposure of the windblown silt similar to that observed in the Mississippi River Valley have also been observed in the lower reaches of the Ohio River Valley. One such location is near Henderson, Kentucky.

The several wind-deposited silts have strikingly uniform and distinguishing engineering characteristics. The silt-sized material, comprising 50-90 percent of the total, is the optimum size for transportation and deposition by wind. The deposits contain minor amounts of fine sand and clay, which are not as effectively and uniformily distributed by means of wind. Loessal soils are generally reworked materials which have been derived from glacial outwash and drift, desert plains, or alluvial plains.

The loessal deposits generally exhibit no stratification but occur in great massive beds. When examined microscopically, the material is seen to consist of sharp-edged fresh particles of quartz, feldspar, calcite and mica. These individual silt particles may be bonded together into aggregates by small amounts of montorillonitic clay or weak carbonate cement. In any event, the bonding material is generally rather sensitive to changes in moisture content.

The natural moisture contents are usually low since the natural deposits are generally well drained because of the characteristic vertical cracks and channels. Generally there is a good correlation between annual rainfall and natural moisture content. However, in certain situations, the natural moisture content may be more controlled by the effects of the underlying materials than by the silt material itself.

If the natural moisture contents are unusually high, the material is usually in its weakest condition. Since the deposit has been subjected to high moisture contents, the bond between the individual silt particles may have been weakened and the material have consolidated to a great extent. Therefore, under loading there may be only an insignificant amount of consolidation. However, because of the relatively low permeability of the silt deposit, the probability is relatively high that pore pressures will increase significantly under load and the material will become "quick" and loose a large amount of its load carrying capability. If the natural moisture contents are low, the material could become significantly weaker if the clay or carbonate bond is subjected to leaching by water. When the natural moisture contents have been low, the deposits generally have a low unit weight because the structure has not yet collapsed due to a weakening of the bond between particles that occurs with high moisture contents.

The natural dry unit weights may range from 65 to 100 pounds per cubic foot. Normally, they are in the range of 80 to 95 pounds per cubic foot. Standard compaction tests give maximum dry unit weights of 105 to 110 pounds per cubic foot. It can be noted, therefore, that there is a significant amount of shrinkage to be taken into account in earthwork computations involving these materials. The loessal deposits are slightly to moderately plastic. Liquid limits typically range between 26 and 34 percent and the plasticity index between 4 and 12 percent.

Loessal deposits are subject to significant modification by local and environmental changes. Increases in the water content tend to result in a loss of strength and an increase in compressibility (See Figure 1). This is due, in part, to 1) the destruction of the clay or carbonate bond, 2) an increase in pore pressure, 3) an increase in the thickness of the double layer water, which, in addition to decreasing the strength makes it possible for a particle of soil to re-orient under subsequent loadings or under overburden.

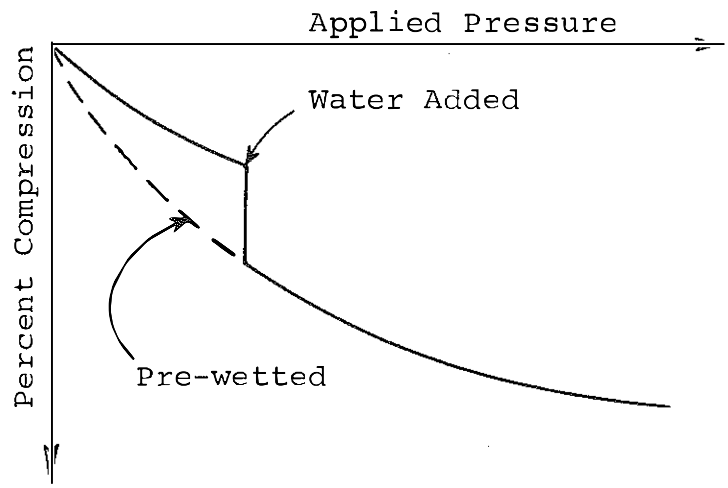

Figure 1. Typical Compression Curve of Water-Sensitive Loess.

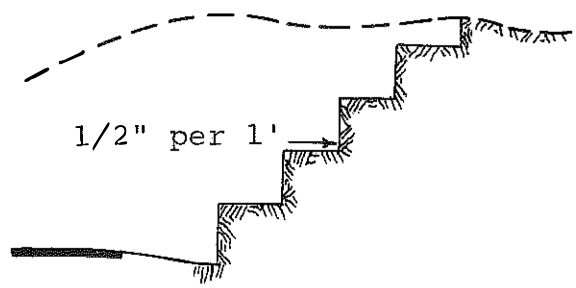

Figure 2. Typical Step Construction with Vertical Walls for Deep Cuts in Loess.

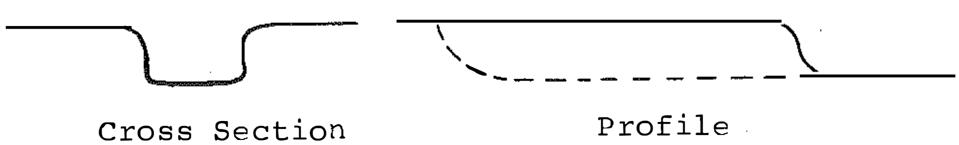

Figure 3. Typical Gullies in Loess Soils.

Loess found in high topographic positions tends to remain at low densities and low moisture contents. If the structure is not disturbed by soaking or manipulation, it is possible to construct foundations involving high contact pressures without shearing failure or excessive settlements. If the material becomes abnormally wet, the soil structure tends to break down and large settlements or shearing failure occurs. When the loess material is located in low topographic positions, the deposits generally have higher densities and higher moisture contents as a result of the soaking that has occurred naturally.

The low-density loesses may be considered as under-consolidated. Upon soaking and (or) loading by an engineering structure, the deposits may become significantly weaker and disastrous settlements may occur. For those loess deposits exhibiting high natural densities, the material may be considered normally consolidated and under loading there may be only a relatively insignificant amount of loss in strength and settlement.

Areas which are covered with thin layers of loess deposits do not have the typical loess problems. The loess tends to lose its identity when it has been deposited in such thin layers and the structure that develops in the material by subsequent modifications is greatly dependent upon the underlying material (e.g. gravels versus clays). When the loess cover is thin, there is also a great deal of intermixing of materials in the construction of an engineering structure and thus a great deal of variability in soil properties in going from loess to clays or sands and gravels.

Because of the unusual characteristics of silts, especially loess, the treatment of these materials in construction projects deserves particular attention of the engineer in order to minimize difficulties which may arise during construction or with regard to maintenance. The performance of these materials are highly dependent upon the density and moisture content. The treatment of water during and after construction is extremely important. These materials are extremely sensitive to water, both in respect to the possible weakening of whatever bonding between particles may exist and because of the possibility of the development of excess pore pressures. Most of the difficulties associated with loess and silt materials can be associated with the presence of water, and many disastrous failures have been noted throughout the world as a result of improper drainage of these materials.

Experience with cuts in true loess soils has indicated that vertical or almost vertical cuts prove to be the most stable and lasting. This is due in a large part to the tendency to break and slough along the vertical channels which naturally develop in these materials. Because of a predominately silty composition of loess soils and because of the resulting low cohesion, these soils are very susceptible to rapid erosion by surface waters. Every effort should be made to prevent rainwater from flowing over the edges of cuts, thus step cuts with vertical faces are often used in deep cuts. In this type of construction, draining of the water away from the cut is usually advisable on the various steps (See Figure 2). In spite of this precaution, however, slices of the material will inevitably breakdown from time to time, again leaving nearly vertical faces that may remain stable for quite some time. To prevent the blocking of traffic in highway cuts, it is generally customary to construct the cut to a somewhat greater width than that called for by the traffic requirements. It must be recognized that some continual maintenance may be required in these types of materials to maintain proper drainage and travelway widths.

As already suggested, silts are highly susceptible to erosional processes, particularly by water. Gullies which are formed in loess generally take on a U-shaped cross section with long flat profiles (See Figures 3 and 4). In addition to surface water erosional susceptibility, silts are subject to piping and erosion by subsurface water flows. This often results in extreme maintenance difficulties near various drainage structures that may be "undermined" by piping.

Because of the possibilities of the development of excess pore pressures, the control of moisture contents in the compaction of silt materials is extremely important. The range over which

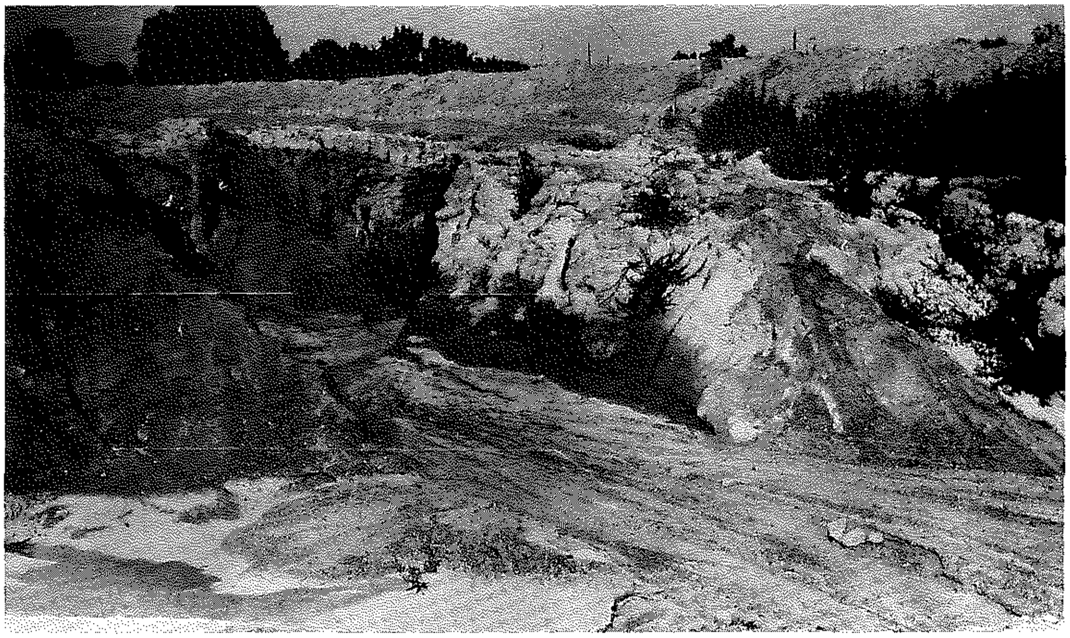

Figure 4a. Photograph Taken During the Construction of US 41 By-Pass (Henderson) Showing the Severe Susceptibility of Silt to Erosion. Note the near vertical walls and long, flat gradient of the gully (1962).

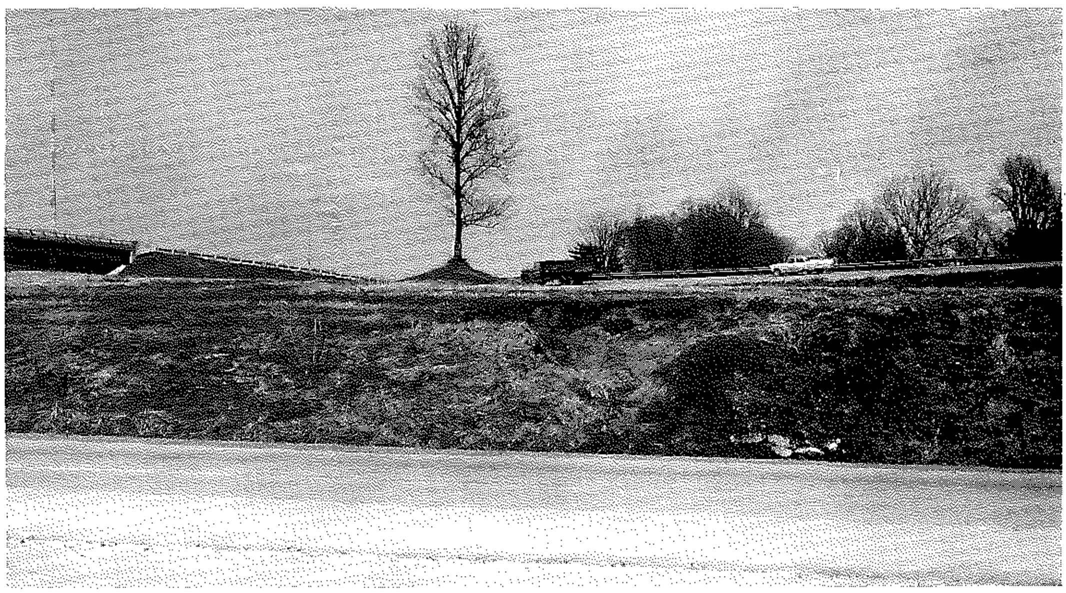

Figure 4b. Photograph of the Same Area Shown in Figure 4a Taken After the Completion of Construction. Note the tendency for the gully to take on the same shape as shown in Figure 4a and to develop in almost the same location (1964).

moisture contents may be permitted to vary is small when compaired with other types of soils. It is extremely easy to overcompact silt materials and therefore induce excess pore pressures. As a result the strength is significantly reduced and the material may become quick (See Figure 5). It is, therefore, very important to control the moisture content during the compaction procedure and never to permit moisture contents to exceed the optimum moisture content for the particular compaction equipment which is being used.

Because of the peculiar sensitivity of silt materials to water, ponding is a construction technique often used to increase the load carrying capabilities of silty materials. This artifical pre-wetting process may produce a completely different structure from that of the natural deposit and thus the properties of the material may be significantly different. Extreme care should be excerised in the pre-wetting or ponding process, however, since it is possible that the material may become so wet that it will be completely unsatisfactory as a foundation or construction material.

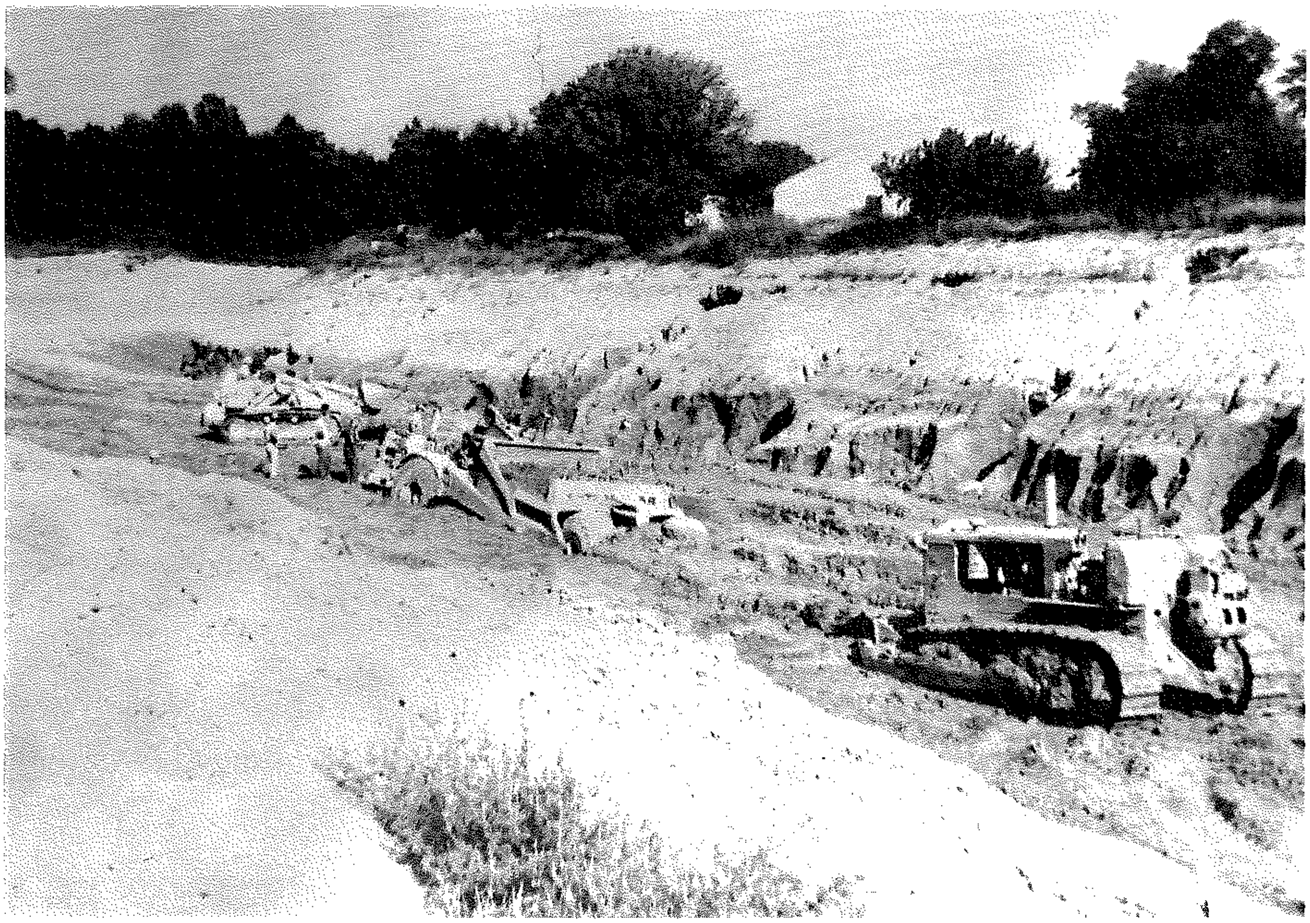

Figure 5. Photograph Taken on the Construction Project of US 41 By-Pass at Henderson Showing the Results Which Can Be Expected When Excess Pore Pressures Develop. Excess pore pressures are induced in the silt material under the load of construction equipment (1962).

CASE STUDIES

US 41 By-Pass, Henderson, Kentucky

U 526 (23)

In the following few pages, a case history will be described and illustrated showing the types of problems which may be encountered during the construction of a high-type highway facility in a soil composed predominately of wind-deposited silt (loess). The conditions which are described were observed during the construction of the US 41 By-Pass around Henderson, Kentucky (See Figure 6).

As a result of subsurface exploration for this project, the materials to depths of at least 30 or 40 feet were described as clays. After the difficulties during the construction period arose, a more detailed investigation indicated that the material was predominately silt. If the physiographic regional concept had been applied in this situation at an early stage of the planning and design of the project, it might have been recognized that there was a relatively good chance that much of the project would have been situated in a wind-blown silt. If this, in fact, had been recognized at an early stage, the designs and construction procedures could have been modified to minimize the effects that were actually encountered.

Near the northern end of the project, the location of a large interchange, there were remnants of relatively high (20 to 35 feet) loessal hills. The southern portion of the project was in similar silty material but the topography was essentially level.

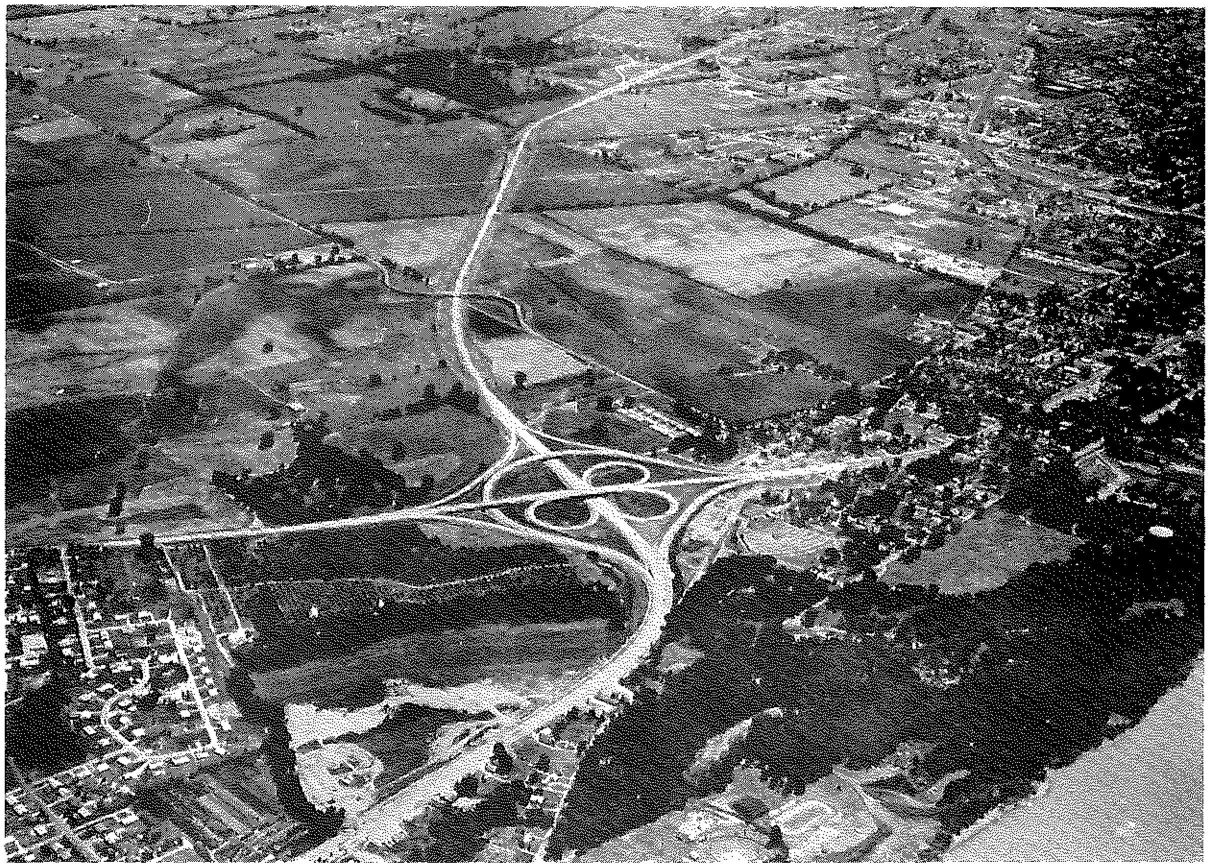

Figure 6. Overall View of the US 41 By-Pass Near Henderson, Kentucky (Looking South) (1964).

The troublesome soil was first encountered on the project in August, 1960. The contractor had extreme difficulty with the soil throughout the entire project (approximately two miles long). On the northern end of the project, the difficulty arose in trying to remove the material from cuts. To the south, the difficulty occurred in borrow pits.

The material causing the grade and drain construction problems appeared to be essentially wind-deposited silt (loess). The moisture associated with the instability difficulties probably resulted from two conditions:

1. The high free water table which may be associated either with heavy clay lenses contained within the river alluvium or with impervious shale layers in the high remnants of the underlying Lisman bedrock formation (See attached geologic reports).
2. Capillary water.

The photographs in Figures 4 through 16 were obtained on the US 41 by-pass construction project at Henderson and illustrate the typical and classical problems which may be encountered when working with these materials.

Table 1. Summary of Soil Test Data, US 41 By-Pass, Henderson, Kentucky (Sampled and Tested by the Division of Research in 1962).

Horizon	Description	Approximate Depth Represented (Feet)	Atterberg Limits LL	Atterberg Limits PI	Std Proctor Max Den (Lb/Ft^3)	Std Proctor OMC (%)	Specific Gravity	CBR Data: Soaking (Days)	Height (Inches)	Swell (Inches)	Swell (%)	Dry CBR	Dry Density	Dry %Max Den	Wet CBR	Wet Density	Wet %Max Den	Moisture Content (%) Pt. of Pen.	Moisture Content (%) Entire
1	Air-Dried Condition Reddish-Brown	0-15	26.2	2.2	106.4	17.1	2.62	2	3.900	.056	1.4	31	105.1	98.8	17	107.0	100.6	18.1	18.8
2	Capillary Water Reddish-Brown	15-25	26.0	0.5	104.0	17.8	2.68	2	4.100	.095	2.3	38	94.7	91.1	9	102.4	98.5	20.7	23.3
3	Capillary Water Mottled Reddish-Brown & Grayish-Blue	25-35	25.6	1.3	104.6	17.8	2.68	4	4.000	.052	1.3	30	100.1	95.7	16	105.4	98.9	20.3	21.3
4	Capillary Water Blue	35+	NL	NP	102.6	17.1	2.68	4	4.000	.054	1.4	40	98.5	96.0	16	102.9	100.3	19.6	20.8
Mean					104.4	17.4	2.67				1.6	35	99.6	95.4	15	103.9	99.6	19.7	21.1
Standard Error					1.4	.4	.08				0.4	4	3.7	2.8	3	1.8	0.9	1.3	1.6

Horizon	Gradation Data: Percentage Passing #60 .25mm	#200 .074mm	.05mm	.02mm	.005mm	.002mm	.001mm	Fractions: Sand .05mm	Silt .05-.005mm	Clay .005mm
1	100	100	98	58	27	21	18	2	71	27
2	100	100	95	53	20	15	15	5	75	20
3	100	100	98	52	18	14	14	2	80	18
4	100	97	95	56	19	16	15	5	76	19
Mean	100	99	96	55	21	17	15	4	75	21
Standard Error	0	1	2	2	4	3	2	2	3	4

Figure 7. Photograph Showing the Results of the Extreme Sensitivity of Silt Materials to Moisture Content. The moisture contents remain at relatively high values as a result of high perched water tables and because of a capillary retention of water by silt materials. When such a material is loaded by construction equipment, for example, the soil becomes quick, loses a large portion of its load carrying capabilities, and thus is completely unable to support even the weight of the construction equipment.

Figure 8. View of Cut Through a Loessal Hill on the Northern End of the US 41 By-Pass Project. A ditch approximately eight to ten feet deep had been excavated at the toe of the embankment shown on the right and had been maintained open throughout a complete winter season and well up into the summer season. Note the extremely wet condition of the roadway area and the high water table shown in the cut slopes by a change in color of the soil material. This high water table and wet condition was observed even after a deep ditch had been opened for several months to permit drainage. This suggests the high capillary retention of water in silt soils and the fact that horizontal drainage is very negligible. Note in the foreground in the roadway area numerous silt boils.

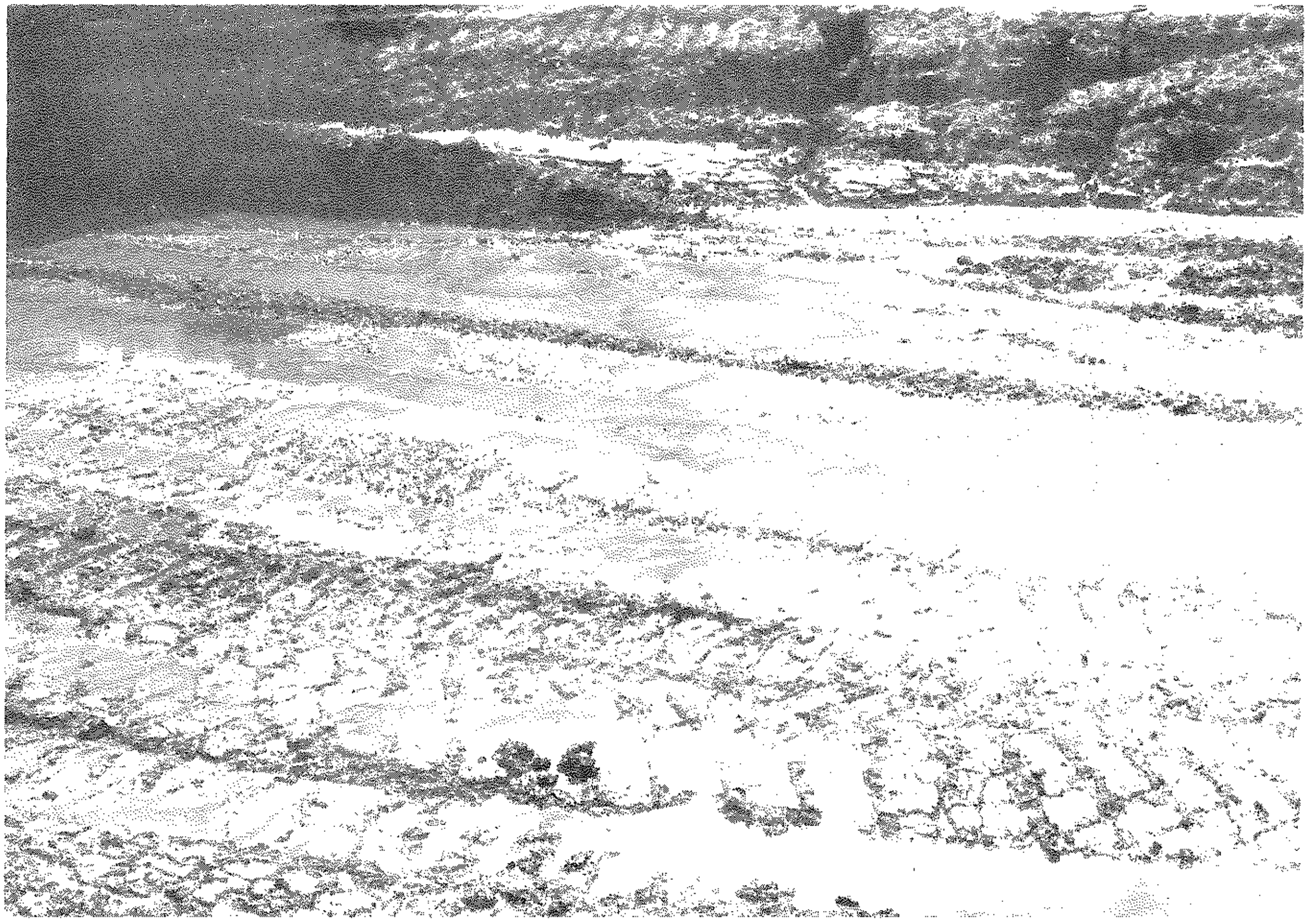

Figure 9. Close-up View of a Number of Silt Boils which Result When the Extremely Wet Silt Material is Loaded by Construction Equipment and the Induced Excess Pore Pressures Cause a Flow of Water in the Direction Offering the Least Resistance. In this particular situation near Henderson, the direction offering the least resistance to flow of the water was in a vertically upward direction; therefore, as the water reached the surface small boils (similar to volcanos) were formed over the surface of the material.

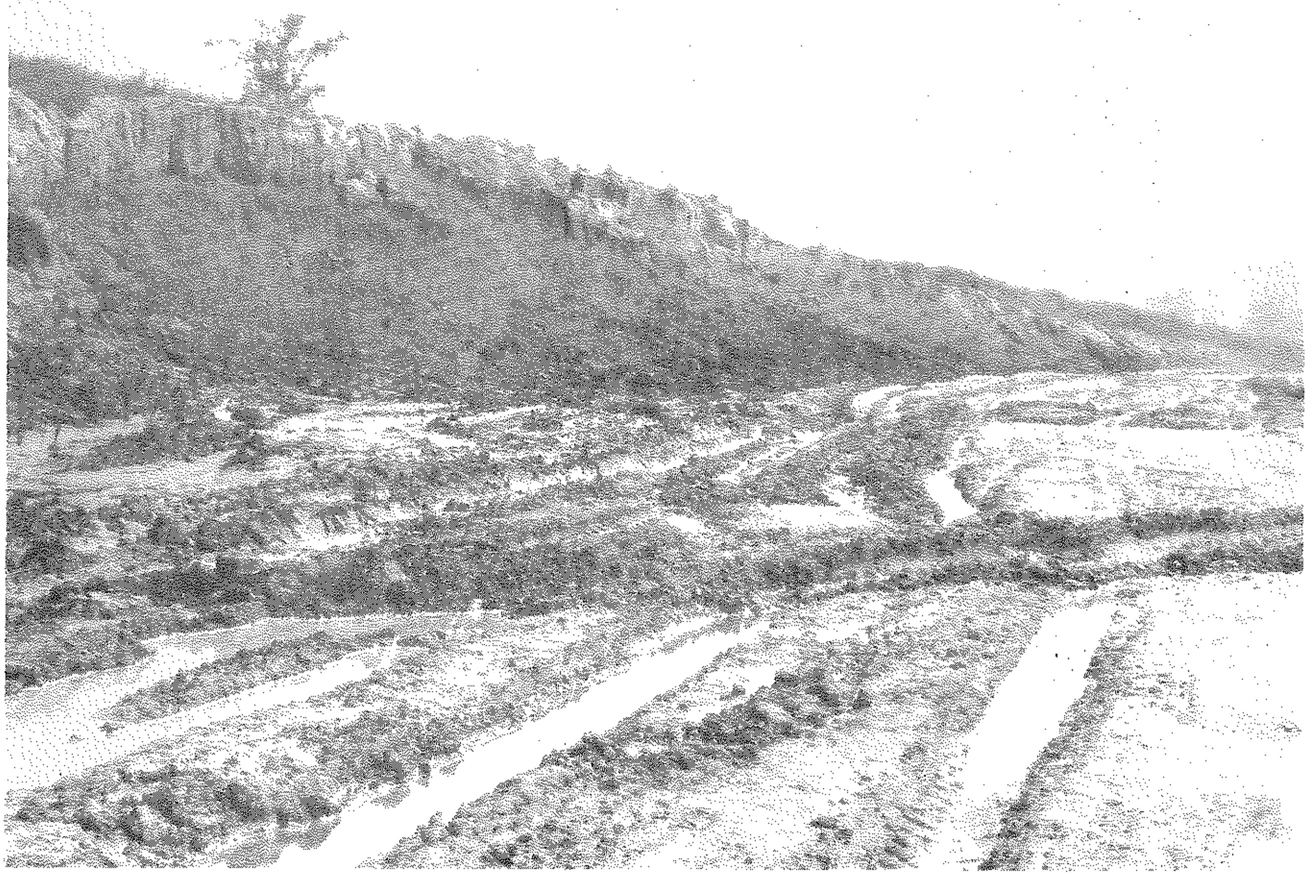

Figure 10. Photograph Showing the Extremely Wet Conditions of an Excavation even After Long Periods of Dry Weather. Note the tendency of the slope to slough on near-vertical walls.

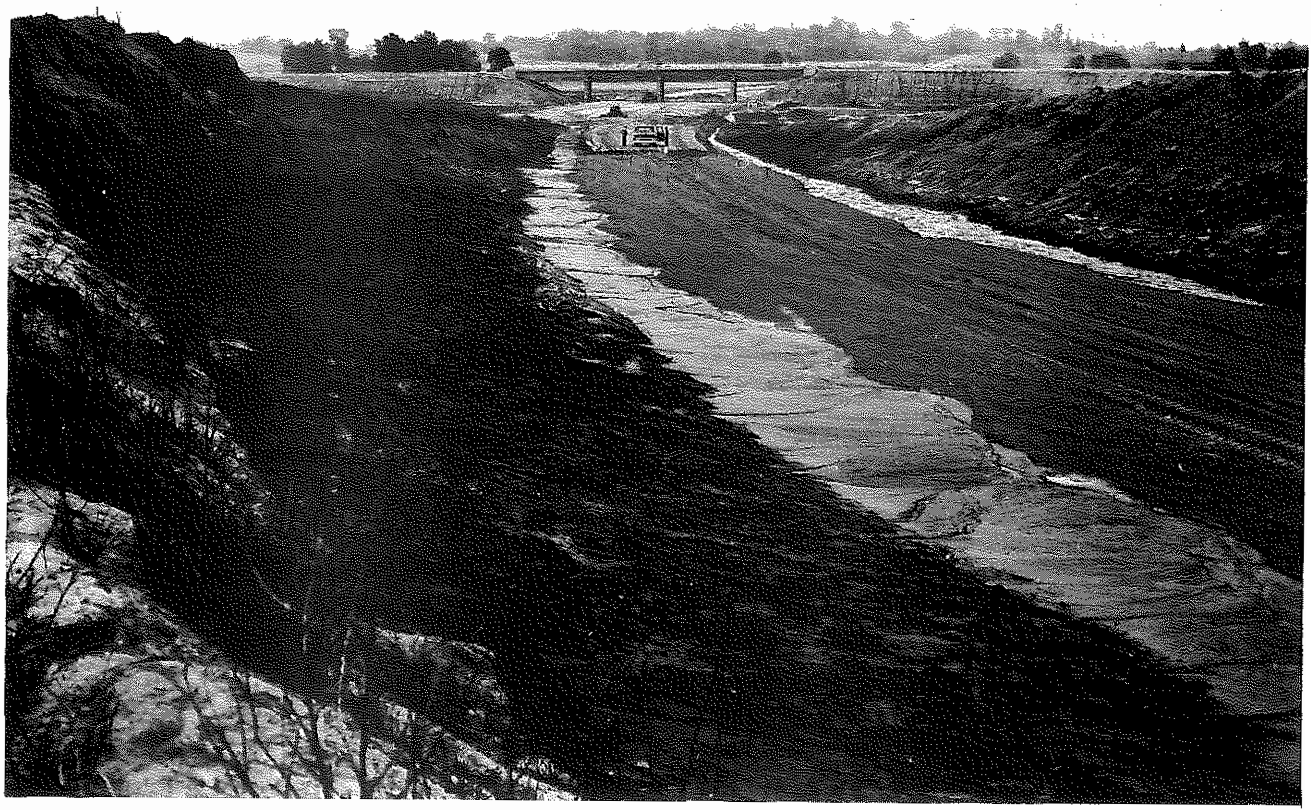

Figure 11. View of Troublesome Cut Area Showing Severe Susceptibility of Silt to Erosion. The material seen in the roadway is a sand blanket placed in an attempt to provide a drainage blanket and a working platform.

Figure 12. View of Troublesome Cut Area Showing the DGA Base in Place.

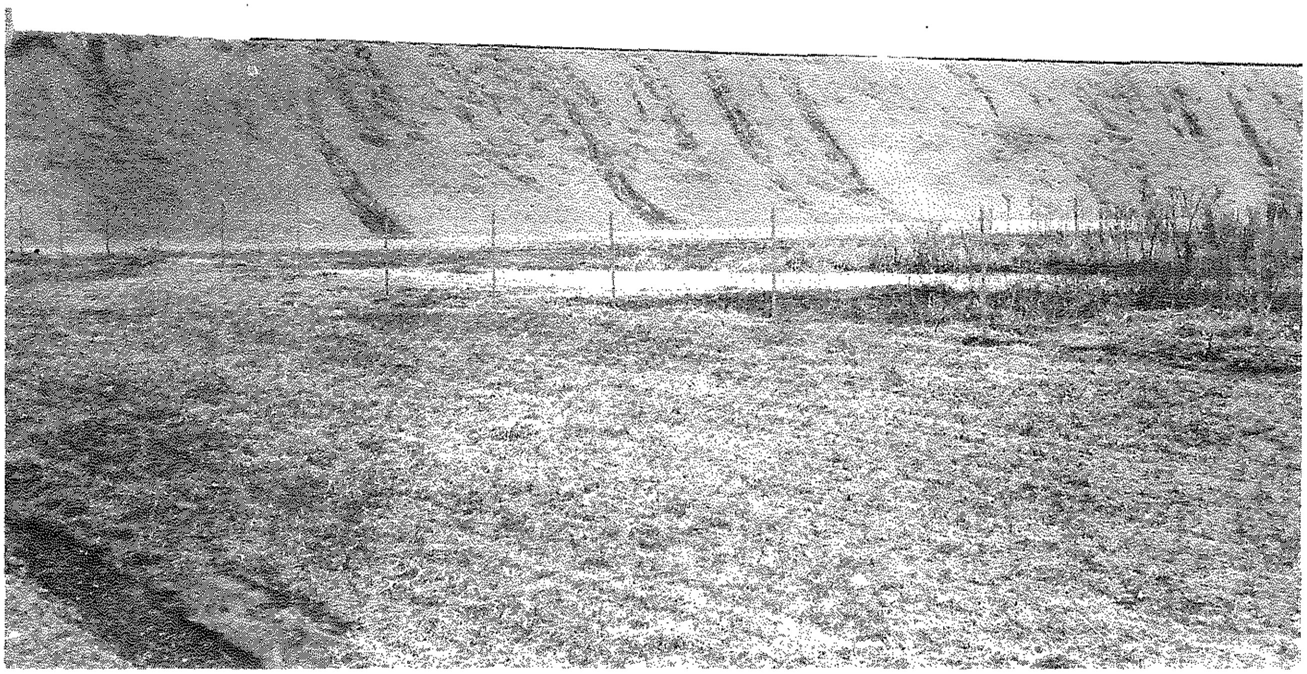

Figure 13. View of Completed Embankment Showing the Extreme Erosion Susceptibility of Silt in Compacted Embankments.

Figure 14. Photograph Taken Soon after the Opening of the By-Pass to Traffic Showing the Extreme Erosion Which Occurs in a Relatively Short Time Around Drainage Structures.

Figure 15. Photograph Showing the Construction of a Paved Ditch at the Top of a Cut Slope.

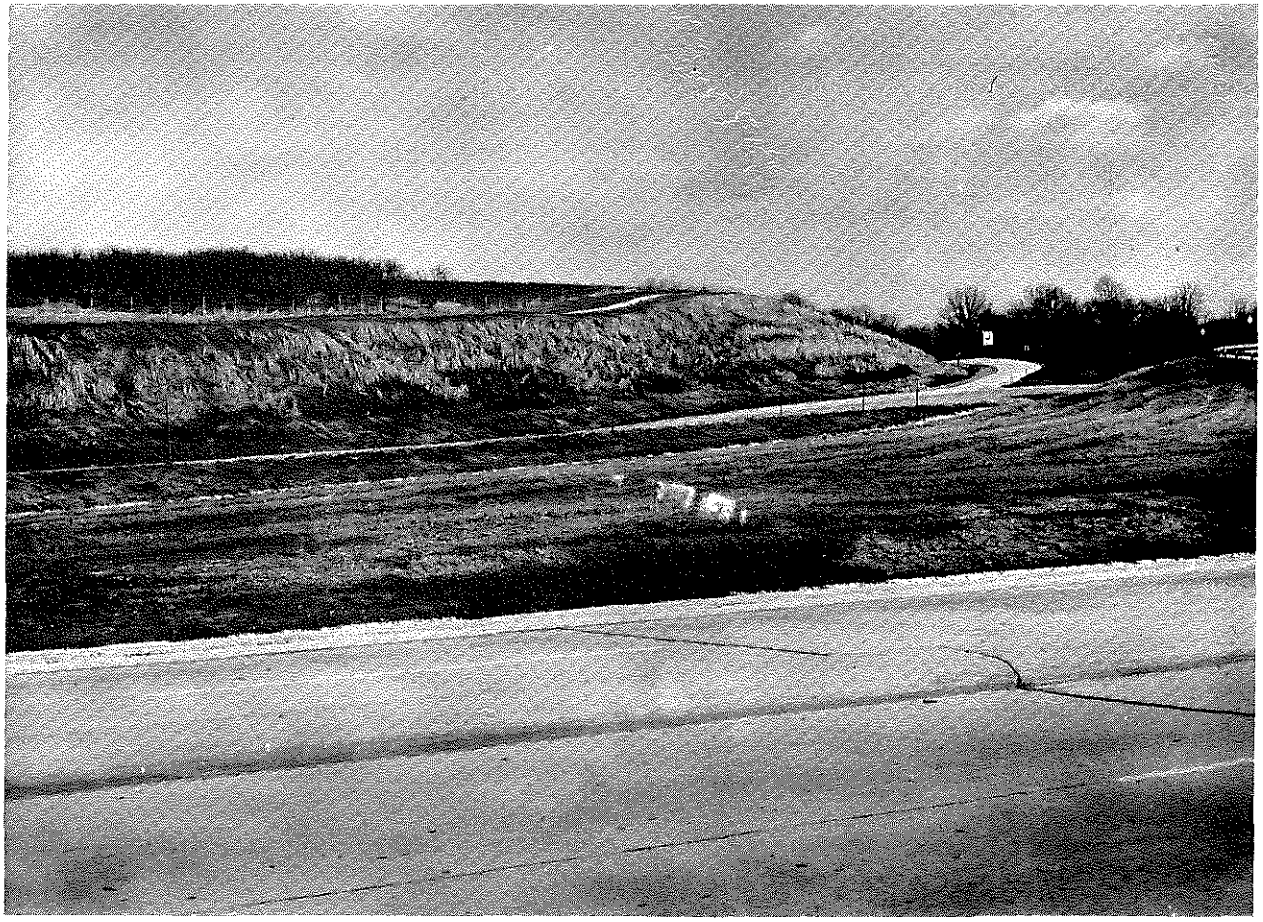

Figure 16. Photograph Showing the Cut Slope Illustrated in Figure 15 and the Benefits Derived in Preventing Surface Water from Flowing over the Edge of the Cut Slope. The paved ditch at the top of the cut was sufficient to carry the water horizontally rather than permitting it to flow over the edge of the slope.

Access Road

Big Rivers Steam-Generating Plant

Henderson County

SP 51-249-1

Construction difficulties were encountered on the access road to the Big Rivers steam-generating plant in Henderson County where a short section of the roadway crossed a pocket of silt material. Part of the excavation in the troublesome area had to be done with a dragline. It was extremely difficult to compact the subgrade, probably because of lack of control of moisture content, and it became necessary to undercut the grade and backfill with an additional 3-inch thickness of dense graded aggregate base. This additional three inches was placed in attempt to provide a working platform, and eventually the material became stabilized as a result of drying of the silt material and compaction under traffic. Approximately three inches of settlement has been observed at the approaches to a bridge site and cut sections warped out of shape after the paving operation had been completed. The construction of this project was completed during October, 1964.

The troublesome soil encountered on this project was very definitely a silty material. It could possibly have been a remnant of a windblown silt that once originally covered widespread areas in this part of the state. It is also possible that the silt encountered on this project could have been associated with marine deposits. In any case, the difficulties encountered were rather typical of those which might be expected when silt materials are involved in a highway construction project.

I 75, Near Berea

Madison County

In the summer of 1966, a pocket of silt material some several hundred feet in length was encountered in the construction of I 75 in Madison County near Berea. The contractor experienced extreme difficulty in compacting the subgrade in one cut area. Eventually the material was removed and select material was brought in to replace it. This troublesome soil was probably a water-deposited material. Tests on samples obtained from the area indicated that approximately 50 percent of the material was of silt size. The remainder of the deposit consisted of 28 percent sand and 22 percent clay. Atterberg limits for the material indicated a liquid limit of 24 and a plasticity index of 5. A standard compaction test on the material gave a maximum dry density of 120 pounds per cubic foot at an optimum moisture content of 14 percent. As would be expected for a silty material, the CBR was extremely high, having a minimum value of 40 in the unsoaked condition and a value of 13 after soaking. The apparent specific gravity of the material was 2.76.

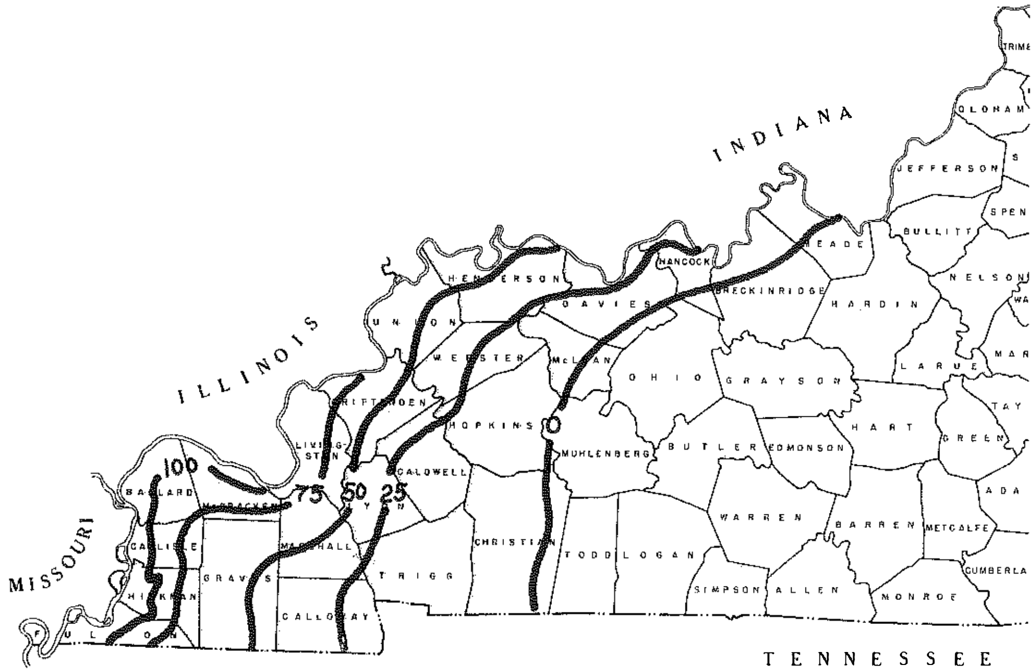

Figure 17. Map of Kentucky showing a general conceptual distribution of loessal deposits. The area indicated in yellow was probably once covered with a mantle of loess. As a result of subsequent erosion, much of this windblown silt has merged into valley alluviums, leaving more or less zonal areas of primary loess and silty residuals at the present time. Isopachs (lines of equal thickness) of the loess are shown in red.

RECOMMENDATIONS

Because of the peculiar characterists of silty materials, it is recommended that extreme caution be taken in the treatment afforded such materials that may be encountered on construction projects located in the western portion of the State of Kentucky. Specifically, it is recommended that:

1. Adequate shrinkage factors should be used to account for the volume change of the silt materials from borrow pits to compacted embankments. In addition, because of the extreme susceptibility of silty materials to erosion, recognition should be given to the possibility of a significant loss of material due to erosion.

2. Extreme care should be exercised in controlling the moisture content of materials to be compacted--not permitting the compaction of silty materials existing at moisture contents higher than the optimum moisture for the compaction equipment being used.

3. Efforts should be made to determine the extent of perched water tables, if they exist at all, that may be encountered during construction.

4. Silty materials are highly susceptibile to erosion by surface waters. It is suggested, therefore, that definite provisions be made to provide erosion control by means of early planting, mulching, and seeding of as much of the area involved in construction as soon as possible. SPECIAL PROVISION NO. 46 RELATIVE TO WATER POLLUTION requires that "...the limits that may be exposed by construction operations at any one time are subject to the approval of the Engineer, and the duration of the exposure of the uncompleted construction shall be as short as practicable. All cut and fill slopes shall be vegetated progressively with construction in so far as practicable. All revegetation work shall be completed prior to the end of the first seeding season following the construction phase..." . The requirements of the

special provision are well taken. However, permitting revegetation work to extend to the end of the first seeding season may permit the erosive silt material to be exposed for an unduly long period of time. The Department has some responsibilities to the public in preventing property damage, stream filling and stream pollution by the highly erosive silt materials that could possibly be encountered in some parts of the State.

REFERENCES

1. Woods, K.B.; Miles, R.D., Lovell, C.W. "Origin, Formation and Distribution of Soils in North America" Chapter 1, Foundation Engineering, Edited by G.A. Leonards, McGraw-Hill, 1962.

2. Deen, R.C.; Scott, G.D.; McGraw, W.W. "Stability Analyses of Earth Masses" Division of Research, Kentucky Department of Highways, September, 1966.

3. Deen, R.C. "Engineering Properties of Kentucky Soils" Division of Research, Kentucky Department of Highways, August, 1966.